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UTILITY
PATENT APPLICATION
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(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. SAT-38

Total Pages

First Named Inventor or Application Identifier

Noriyuki Shiba et al.

Express Mail Label No.

EL 528788459US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
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1. Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

2. Specification [Total Pages 19]
(preferred arrangement set forth below)
 - Descriptive title of the Invention
 - Cross References to Related Applications
 - Statement Regarding Fed sponsored R & D
 - Reference to Microfiche Appendix
 - Background of the Invention
 - Brief Summary of the Invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claim(s)
 - Abstract of the Disclosure

3. Drawing(s) (35 USC 113) [Total Sheets 4]

4. Oath or Declaration [Total Pages 23]
 a. Newly executed (original or copy)
 b. Copy from a prior application (37 CFR 1.63(d))
 (for continuation/divisional with Box 17 completed)
 [Note Box 5 below]
 i. DELETION OF INVENTOR(S)
 Signed statement attached deleting
 inventor(s) named in the prior application,
 see 37 CFR 1.63(d)(2) and 1.33(b).

5. Incorporation By Reference (useable if Box 4b is checked)
 The entire disclosure of the prior application, from which a
 copy of the oath or declaration is supplied under Box 4b,
 is considered as being part of the disclosure of the
 accompanying application and is hereby incorporated by
 reference therein.

6. Microfiche Computer Program (Appendix)

7. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
 a. Computer Readable Copy
 b. Paper Copy (identical to computer copy)
 c. Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. Assignment Papers (cover sheet & document(s))

9. 37 CFR 3.73(b) Statement Power of Attorney
(when there is an assignee)

10. English Translation Document (if applicable)

11. Information Disclosure Statement (IDS)/PTO-1449 Copies of IDS
Citations

12. Preliminary Amendment

13. Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)

14. Small Entity Statement filed in prior application,
Statement(s) Status still proper and desired

15. Certified Copy of Priority Document(s)
(if foreign priority is claimed) **to follow**

16. Other: **Claim of Priority**

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

 Continuation Divisional Continuation-in-part (CIP)

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PATENTS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Noriyuki Shiba et al.

Docket: SAT-38

Serial No.

Filed:

For: METHOD AND DEVICE FOR SYNCHRONIZATION CONTROL

600 Third Avenue
New York, NY 10016
December 16, 1999

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

SIR:

This is a Preliminary Amendment in the above-identified case.

Please amend the application as follows:

IN THE SPECIFICATION:

Page 3, lines 18 and 19, change "~~Δθ/ΔT~~" to --Δθ/ΔT--.

Page 3, lines 18 and 21, change "~~ΔT~~" to --ΔT--.

Page 4, lines 3 and 6, change "~~Δθ~~" to --Δθ--.

Page 10, line 23, change "~~Δθ~~" to --Δθ--.

REMARKS

The above amendments are to correct obvious typographical errors in the specification.

Respectfully submitted,
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METHOD AND DEVICE FOR SYNCHRONIZATION CONTROL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a device and a method for controlling synchronization where machine shafts are electrically-driven and in phased synchronism by plural, mutually accurate, electric motors. Such shafts may be found in conveyor systems, processing systems for resins and metals, and rotary presses.

2. Background of the Invention

When synchronization control is effected by electrically keeping mutual phases of plural electric motors (or mechanical shafts driven by those electric motors) unchanged, it is necessary to first match the "origins" (or starting points or reference points) of those electric motors or mechanical shafts, and then effect synchronization control.

For matching origins, a conventional method uses an origin detector provided on each electric motor or each rotating machine shaft to detect a machine origin. The electric motor is then interrupted, and the origins of all other electric motors are then detected. When detection of all origins for all motors is complete, synchronous operation is begun. In this way, a time of 30 to 50 seconds is required until the matching has been completed. This lengthens waiting time, causing poor working efficiency.

To solve such a difficulty, a recently proposed method matches the origins of plural electric motors in an improved manner, i.e., the matching of origins is achieved without once interrupting the electric motors during low rotational frequency operation.

FIG. 6 illustrates a prior art example in which matching of origins is effected during low rotational frequency operation of electric motors. In FIG. 6, two electric motors are exemplarily used in the matching of origins of plural electric motors for brevity of the description.

In FIG. 6, M_m , M_{s1} are electric motors in a master section and a slave section, P_m , P_{s1} are incremental encoders each coupled with the machine shafts driven by the electric motors, and R_m , R_{s1} are the rotating machine shafts driven by the electric motors. Machine origins G_m , G_{s1} are mounted on the machine shafts R_m , R_{s1} , which origins are detected by detectors K_m , K_{s1} . The aforementioned master and slave electric motors M_m , M_{s1} are driven respectively by drivers D_m , D_{s1} and controllers A_m , A_{s1} .

The aforesaid controller A_m drives the electric motor M_m through the driver D_m following a rotational frequency instruction provided from a concentrated controller C by obtaining a rotational frequency signal through a rotational frequency detector F_m from a continuous pulse signal outputted by the aforementioned incremental encoder P_m , and feeding the rotational frequency signal back.

In the following discussion, the arrangement of the aforementioned controller A_{s1} of the slave section in FIG. 6 will be described.

In the controller A_{s1} a rotational frequency instruction is detected by the rotational frequency detector S_{s1} from the pulse signal obtained from the

aforementioned incremental encoder P_m of the master section. Further, a feedback rotational frequency of the slave section is detected from the incremental encoder P_{sl} and the rotational frequency detector F_{sl} of the slave section.

Herein, a cumulative counter C_{sl} is cleared when the aforesaid detector K_m of the master section detects the machine origin, and counts a pulse train of the aforesaid incremental encoder P_{sl} of the slave section.

The counted value of the cumulative counter C_{sl} is stored in a Z correlation distance memory area Z_{sl} with the aid of a switch RY_{sl} , actuated when the detector K_{sl} of the slave section detects the machine origin. More specifically, the stored value in the Z correlation distance memory part Z_{sl} indicates a Z correlation distance $\Delta\theta$ obtained by measuring the phase difference of the mechanical origins of the master and the slave with the number of pulses of the aforesaid P_{sl} of the slave section.

When the origins are matched, two electric motors are actuated and run at a low rotational frequency with a rotational frequency instruction of the aforesaid centralized controller C . In the slave section, the z correlation distance $\Delta\theta$ is read out from the z correlation Z_{sl} in the operation at the low rotational frequency, and $\Delta\theta/\Delta t$ is calculated in order to adjust the time Δt , and a correction value of the $\Delta\theta/\Delta t$ is subtracted from the rotational frequency instruction by the aforesaid rotational frequency detector S_{sl} of the slave section. The correction is executed for the time Δt with the switch RY_{s2} .

Two electric motors are matched in origins thereof by adjusting the rotational frequency of the slave section as described above, and are changed over to synchronization control and then accelerated into ordinary rotational frequency operation.

The prior art method and apparatus however suffer from difficulties that even when the origin matching is effected while operating the electric motors, the Z correlation distance $\Delta\theta$ is detected by allowing the electric motors of the master and slave to rotate by one revolution or more, so that much time is required for the detection, and it takes 20 to 40 seconds until the origin matching is completed.

Further, in order to detect the Z correlation distance $\Delta\theta$ it is needed that the rotational frequency of the master and slave electric motors are stabilized and they are operated at the same rotational frequency to the utmost, so that the origin matching must be done at a low rotational frequency, which causes a complicated adjustment.

Furthermore, when there are electric motors under operation and electric motors under interruption and the electric motors under interruption are started for synchronization control, the electric motors already in operation must be operated once at a low rotational frequency for the origin matching, and hence an operation procedure is complicated and much time is required.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a synchronization control device and a synchronization control method in which it is capable of achieving origin matching in a short time continuously in operation of the electric motors without once interrupting the electric motors whether they are operated at low rotational frequency or normal rotational frequency and is capable of shifting the operation to ordinary synchronization operation, and in which it is capable of, even when synchronization operations for electric motors are performed in ordinary

operation and for stopped electric motors, starting the stopped electric motors to achieve origin matching in the operation of the electric motors to continuously shift the operation to ordinary synchronization operation without bringing the electric motors in operation into a low rotational frequency.

According to the present invention, for synchronization control of machine shafts driven by electric motors, one electric motor is disposed in a master section and the other one or plural electric motors is or are disposed in a slave section. A rotary encoder composed of an absolute encoder or a Z phase equipped incremental encoder is provided on the electric motors of the master section and the slave section or on machine shafts driven by the electric motors to output a signal in response to rotation of the electric motor or the machine shaft. For the aforesaid rotary encoder there may be employed one attached to each electric motor (rotary encoder mounted on the electric motor for detecting rotation of the electric motor), and the rotary encoder may be coupled with a machine shaft connected with a rotary shaft of each electric motor or coupled with a machine shaft connected through a gear and the like.

The electric motor of the master section is driven by ordinary rotational frequency control. A controller of the electric motor of the slave section detects at all times both a rotational frequency and a rotation phase of the aforesaid electric motor or the machine shaft based upon a signal from the rotary encoder of the master section, and detects at all times both a rotational frequency and a rotation phase of the electric motor of the slave or the machine shaft driven by the electric motor based upon a signal from the rotary encoder of the slave section.

The controller of the electric motor of the slave section calculates at all times a synchronization phase deviation from the rotation phase of the master and it of the slave both detected at all times as described above.

In the synchronization control device constructed as described above, when plural electric motors are all operated from a stopped state, they are increased in their rotational frequency first from a low rotational frequency to a predetermined rotational frequency irrespective of an ordinary rotational frequency. The electric motor of the master section is increased in its rotational frequency with ordinary rotational frequency control, and the electric motor of the slave section or the machine shaft driven by the electric motor is increased in its rotational frequency taking a signal detected from the rotary encoder of the master section as a rotational frequency instruction.

After the electric motor of each slave section is in acceleration or reaches a predetermined rotational frequency, the synchronization phase deviation of the master and the slave calculated at all times is added to the rotational frequency instruction as a correction value. Each slave section rapidly completes the origin matching as described above.

Each slave section adds at all times the synchronization phase deviation of the master and slave sections to the rotational frequency instruction as a correction value even after the origin matching is completed, and clearly continues the synchronization control with the same action as the origin matching even under ordinary operation on and after the operation.

Although in the above description the electric motor is provided on the master section, and a rotational frequency signal and a phase signal are outputted from the rotary encoder attached to the electric motor provided on the master section or

coupled with the machine shaft driven by the electric motor, a rotational frequency signal and a phase signal corresponding to the signal outputted from the aforesaid rotary encoder are electronically generated without provision of the electric motor on the master section and are outputted from the master section, and the rotation phase of the electric motor of the slave section or of the machine shaft driven by the electric motor may be controlled on the basis of the rotational frequency signal and the phase signal.

In the present invention, as described above, the synchronization phase deviation of the master and the slave is detected at all times, which deviation is in turn employed as a correction signal to rapidly complete the origin matching and eliminate the need of a changeover of the control upon the origin matching and in transfer to ordinary synchronization control and hence bring very high practicability.

According to the present invention, when plural electric motors are operated from an all-stopped state, the origin matching is clearly ensured even in acceleration without waiting arrival to a predetermined rotational frequency.

Further, according to the present invention, in plural electric motors in operation at an ordinary rotational frequency and the electric motors of the slave section out of operation, in order that the origin matching of the stopped electric motors is effected to add those electric motors to the synchronization control, the stopped electric motors of the slave section are started, and the rotational frequency of the master section detected from the rotary encoder of the master section is increased as the rotational frequency instruction. The slave section, after reaching a predetermined rotational frequency, adds the synchronization phase deviation of the slave and the master to the rotational frequency instruction as a correction. The slave section

rapidly completes the original point matching and shifts the operation to the synchronization control.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of illustrative example.

FIG. 1 is a view illustrating a preferred embodiment of matching an origin according to the present invention;

FIG. 2 is a view illustrating detection of phase deviation among plural electric motors;

FIG. 3 is a view illustrating operation when plural stopped electric motors are started, and origin matching is effected after completion of acceleration according to the present invention;

FIG. 4 is a view illustrating the operation when plural stopped electric motors are started, and the origin matching is effected in acceleration according to the present invention;

FIG. 5 is a view illustrating the operation when plural stopped electric motors are started, and the origin matching is effected for other electric motors in operation according to the present invention; and

FIG. 6 is a view illustrating a prior art example wherein origin matching is effected for synchronization control.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following, preferred embodiments will be described in detail with reference to the accompanying drawings. FIG. 1 illustrates a preferred embodiment of the present invention where plural electric motors are matched in origins thereof, Figs. 2, 3, 4, and 5 are views each illustrating operation of a preferred embodiment illustrated in FIG. 1.

FIG. 1 exemplarily illustrates synchronization control of a master section and two slave sections in order to simply describe plural electric motors according to the present invention, in which the same symbols shall be applied to portions overlapping on portions in FIG. 6 illustrating a prior art example.

In FIG. 1, M_m is an electric motor of the master section, $Ms1$, $Ms2$ are electric motors of the slave section, respectively, and Pm , $Ps1$, $Ps2$ are incremental encoders coupled with the aforesaid electric motors. For the rotary encoders coupled with the electric motors of the master section and the slave section 1, 2, there is available an absolute encoder or a Z phase equipped incremental encoder. In the embodiment in FIG. 1, there is illustrated an example where there are used the Z phase equipped incremental encoders Pm , $Ps1$, $Ps2$, in which controllers Am , $As1$ of the electric motors receive a Z phase pulse Zp once for one revolution of the electric motor and a pulse series Rp in response to the rotation of the electric motor from the incremental encoders Pm , $Ps1$, $Ps2$.

Although in the present embodiment, there is described the case where the rotary encoder is additionally provided on the electric motor, a rotary encoder may be coupled with a machine shaft connected with the electric motor through a gear and the like.

The controller Am of the master section obtains a rotational frequency signal from a continuous pulse series Rp outputted from the incremental encoder Pm with a rotational frequency detector Fm, and feeds back the rotational frequency signal to control the operation such that the rotational frequency of the aforesaid electric motor Mm is coincident with a rotational frequency instruction provided from the concentrated controller C.

The aforesaid controller As1 of the slave sections 1, 2 detects a rotational frequency instruction from the pulse signal obtained from the incremental encoder Pm with the aid of the rotational frequency detector Ss1, and further detects a feedback rotational frequency of the slave section from the incremental encoders Ps1, Ps2 of the slave section with the aid of the rotational frequency detector Fs1 and controls the operation such that the rotational frequency of the electric motor Ms1 is coincident with that of the electric motor Mm.

The master phase counter Cm1 of the controller As1 of the slave sections 1, 2 counts the pulse series Rp from the incremental encoder Pm of the master section and is cleared with the Z phase pulse Zp, whereby the rotation phase of the electric motor Mm of the master section is detected at all times.

Simultaneously, the slave phase counter Cs1 counts the pulse series Rp of the incremental encoder Ps1 of the slave section and is cleared with the Z phase pulse Zp, whereby the rotation phases of the electric motors Ms1, Ms2 of the slave section are detected at all times.

Counted values of the phase counters Cm1 and Cs1 are inputted into the phase deviation calculator Hs1 in which the phase deviation $\Delta\theta$ is calculated. The phase deviation $\Delta\theta$ is held in the phase deviation calculator Hs1 at all times, and when the contact PYs1 is closed as in the case where origins are matched or synchronization

is controlled, a rotational frequency instruction detected by the rotational frequency detector Ss1 is corrected with an output of the phase deviation calculator Hs1.

Further, an offset signal outputted from an offset signal generator Os1 is added to the output of the phase deviation calculator Hs1, whereby predetermined offset is provided between rotation phases of the electric motor Mm of the master section and them of the electric motor Ms1 of the slave section.

FIG. 2 is a view further illustrating the operations of the master phase counter Cm1 and the slave phase counter Cs1.

FIG. 2(a) illustrates operation of the master phase counter Cm1, and FIG. 2(b) illustrates operation of the slave phase counter Cs1.

As illustrated in the same figure, the master phase counter Cm1 is cleared with the Z phase pulse Zp of the incremental encoder Pm of the master section, and counts the pulse series Rp in response to the rotation of the incremental encoder Pm.

As clarified from this, the master phase counter Cm1 detects the rotation phase of the electric motor of the master section.

Likewise, the slave phase counter Cs1 is cleared with the Z phase pulse Zp of the incremental encoder Ps1 of the slave section, and counts the pulse series Rp in response to the rotation from the incremental encoder Ps1 to hereby detect the rotating phase of the electric motor of the slave section.

Outputs of the master phase counter Cm1 and the slave phase counter Cs1 are inputted into the phase deviation calculator Hs1, and the phase deviation calculator Hs1 calculates a phase deviation Hs in accordance with the following formula:

$$Hs = N_{max} \times Covf + Cm - Cs \quad (1)$$

In the formula (1), Nmax is a pulse number per one revolution of the Z phase-equipped incremental encoders Pm, Ps1, and Covf is a counted value of overflow

pulses of the master phase counter $Cm1$ and the slave phase counter $Cs1$ which value is added one by one every time the master phase counter $Cm1$ overflows and is subtracted one by one every time the slave phase counter $Cs1$ overflows. Cm and Cs are count values of the master phase counter $Cm1$ and the slave phase counter $Cs1$.

Once the electric motors Mm , $Ms1$ of the master and slave sections are driven, the aforesaid phase counters $Cm1$ and $Cs1$ are operated as illustrated in FIG. 2.

First, at the instant of the operation "original matching input" at time point A in FIG. 2 the aforesaid counted value $Covf$ is cleared. At the time point, $Covf = 0$, and the phase deviation Hs is calculated from the following formula:

$$Hs = Cm - Cs \quad (2)$$

Then, at a point B the master phase counter $Cm1$ overflows, so that $Covf=1$ is attained, and hence the phase deviation Hs at the point B is calculated from the following formula:

$$Hs = N_{max} \times 1 + Cm - Cs \quad (3)$$

Then, since at a point C the slave phase counter $Cs1$ is overflowed, $Covf=0$ holds, and the phase deviation Hs at the point C is obtained with the following formula:

$$Hs = N_{max} \times 0 + Cm - Cs \quad (4)$$

Matching of the slave section with the master section in their original points is realized by calculating the phase deviation Hs , and subtracting the phase deviation Hs from a rotational frequency instruction outputted by the rotational frequency detector $Ss1$ as described above, and hence the original point matching at a point D illustrated in FIG. 3 is completed.

FIG. 3 is a view illustrating the operation of the origin matching where plural electric motors start their operations from all interrupted state. Once the operation is

started, the electric motors of the master section and the electric motors of the slave section are accelerated up to arbitrary rotational frequency with an ordinary rotational frequency instruction.

When the contact RYs1 is closed at the point A where the rotational frequency is kept unchanged, the rotational frequency instruction detected by the rotational frequency detector Ss1 is corrected with the output of the phase deviation calculator Hs1, and the origin matching is completed at the point D where the phase deviation Hs becomes zero.

FIG. 4 is a view illustrating operation where plural electric motors start their operations from all interruption state and the origin matching is performed during acceleration. Once the operation is started, the contact RYs1 is closed during the acceleration, and a rotational frequency instruction detected by the rotational frequency detector Ss1 is corrected with an output of the phase deviation calculator Hs1, and likewise the origin matching is completed.

FIG. 5 is a view illustrating the operation of the present embodiment wherein there are electric motors in operation and stopped electric motors among plural electric motors, and the stopped electric motors start their operation to be accelerated up to the rotational frequency of the electric motors in operation, and after completion of the acceleration the origin matching is performed. The slave section starting its operation anew is accelerated up to substantially same rotational frequency as that of the section already in operation, and thereafter the origin matching is started at the point A as described previously. The origin matching is achieved with the aid of the action of the aforesaid phase deviation Hs, and the origin matching is completed at the point D where the phase deviation Hs becomes 0.

Although in the present preferred embodiment illustrated in FIG. 1 there was described the situation where the electric motors are provided in the master section, and where there was performed the synchronization control between machine shafts driven by the electric motors and machine shafts driven by the electric motors provided in the slave section, there may be provided in the concentrated controller C means for electronically generating a rotational frequency signal outputted from the incremental encoder P_m and a signal corresponding to the phase signal as described previously, which concentrated controller C may be operated as the master section.

More specifically, signals corresponding to the rotational frequency signal and the phase signal are electronically generated in the concentrated controller C, which signals are in turn provided to the master phase counter C_{m1} of the slave section as described in the aforesaid preferred embodiment, whereby the signals corresponding to the rotational frequency signal and the phase signal can be synchronized with the machine shaft of the electric motor of the slave section.

What is claimed is:

1. A synchronization controller including controllers of a master section and a slave section both for controlling an electric motor, said synchronization controller serving to accurately synchronize a rotational frequency and a rotation phase of said electric motor or a machine shaft driven by said electric motor, said slave section controller comprising (a), (b), (c) as below therein,

(a) a master rotational frequency detection means and a master phase detection means for detecting simultaneously at all times a rotational frequency signal and a phase signal from an output of a rotary encoder belonging to the electric

motor of the master section or from an output of a rotary encoder coupled with the machine shaft driven by said electric motor;

(b) a slave rotational frequency detection means and a slave phase detection means for detecting simultaneously at all times a rotational frequency signal and a phase signal from an output of a rotary encoder belonging to the electric motor of the slave section or from an output of a rotary encoder coupled with the machine shaft driven by said electric motor; and

(c) a phase deviation detection means for detecting a phase deviation from the outputs of said master phase detection means and said slave phase detection means at all times,

there being matched an origin of the electric motor of the master section and it of the slave section, or matched an origin of the machine shaft driven by the electric motor of the master section and it driven by the electric motor of the slave section based upon the phase deviation detected by said phase deviation detection means to achieve synchronous control.

2. A synchronization controller including a controller of a slave section for controlling an electric motor, said synchronization controller serving to accurately synchronize a rotational frequency and rotation phase of said electric motor or a machine shaft driven by said electric motor with a rotational frequency and a phase signal outputted from the master section, said slave section controller comprising:

(a) a master rotational frequency detection means and a master phase detection means for simultaneously detecting the rotational frequency signal and the phase signal outputted from the master section at all times;

(b) a slave rotational frequency detection means and a slave phase detection means for detecting simultaneously at all times the rotational frequency signal and

the phase signal from an output of a rotary encoder belonging to the electric motor of the slave section or from an output from a rotary encoder coupled with the machine shaft driven by the electric motor; and

(c) a phase deviation detection means for detecting a phase deviation from the outputs of said master phase detection means and said slave phase detection means at all times,

there being matched an origin of the electric motor of the slave section or the machine shaft driven by the electric motor based upon the phase deviation detected by said phase deviation detection means to synchronize rotation phase of said electric motor or the machine shaft driven by said electric motor with the signal outputted from the master section.

3. A synchronization control method including an electric motor for driving a rotating machine shaft and a controller for a master section and a slave section both for controlling said electric motor, said synchronization control method serving to accurately synchronize a rotational frequency and rotation phase of said electric motor or the machine shaft driven by said electric motor, comprising the steps of:

when plural electric motors for executing the synchronization control starts its operation from a stopped state simultaneously detecting at all times a rotational frequency signal and a phase signal of the electric motor of the master section or of a machine shaft driven by said electric motor in the slave section and further simultaneously detecting at all times a rotational frequency signal and a phase signal of the electric motor of the slave section or of the machine shaft driven by the electric motor;

obtaining a phase deviation from said rotational frequency signal and said phase signal; and

matching origins of said electric motors of each slave section or of machine shafts driven by said electric motors based upon said phase deviation during acceleration of all number of the electric motors or after all number of the electric motors reach a predetermined rotational frequency, and synchronizing the rotation phase of said electric motor or of the machine shaft with the phase signal outputted from the master section.

4. A synchronization control method including an electric motor for driving a rotating machine shaft and a controller for a master section and a slave section both for controlling said electric motor, said synchronization control method serving to accurately synchronize a rotational frequency and rotation phase of said electric motor or the machine shaft driven by said electric motor, comprising the steps of:

among the electric motors for effecting synchronization control there are some electric motors under operation and others electric motors in operation and the operation of the electric motors under interruption is started, simultaneously detecting rotational frequency signals and phase signals of the electric motors of the master section or the machine shafts driven by said electric motors at all times in the slave section and further simultaneously detecting the rotational frequency signals and the phase signals of the electric motors of the slave section or of the machine shafts driven by said electric motors at all times;

obtaining a phase deviation from the rotational frequency signals and the phase signals; and

matching origins of the electric motors of each slave section or of the machine shafts driven by the electric motors based upon said phase deviation after said electric motors reach a predetermined rotational frequency to synchronize the

rotation phase of the electric motor or of the machine shaft with the phase signal outputted from the master section.

ABSTRACT OF THE DISCLOSURE

A synchronization control device and a synchronization control method are provided in which it includes controllers Am and Asl of a master section and a slave section for accurately synchronizing rotational frequency and rotation phases of driving electric motors Mm and Msl. The controller Asl includes rotational frequency detectors Ssl, Fsl, a master phase counter Cml, and a slave phase counter Csl, and detects at all times both of a rotational frequency and a rotation phase of the electric motors Mm of the master based upon an output of the rotary encoder Pm, and further detects at all times both of a rotational frequency and a rotation phase of the electric motor Msl of the slave. A phase deviation calculator Hsl is provided to calculate synchronization phase deviation at all times, and when a switch RYsl is actuated, it corrects an output of the rotational frequency detection means Ssl based upon the phase deviation and matches origins of the electric motors of the master section and the slave section to shift the operation to synchronization control.

Fig.1

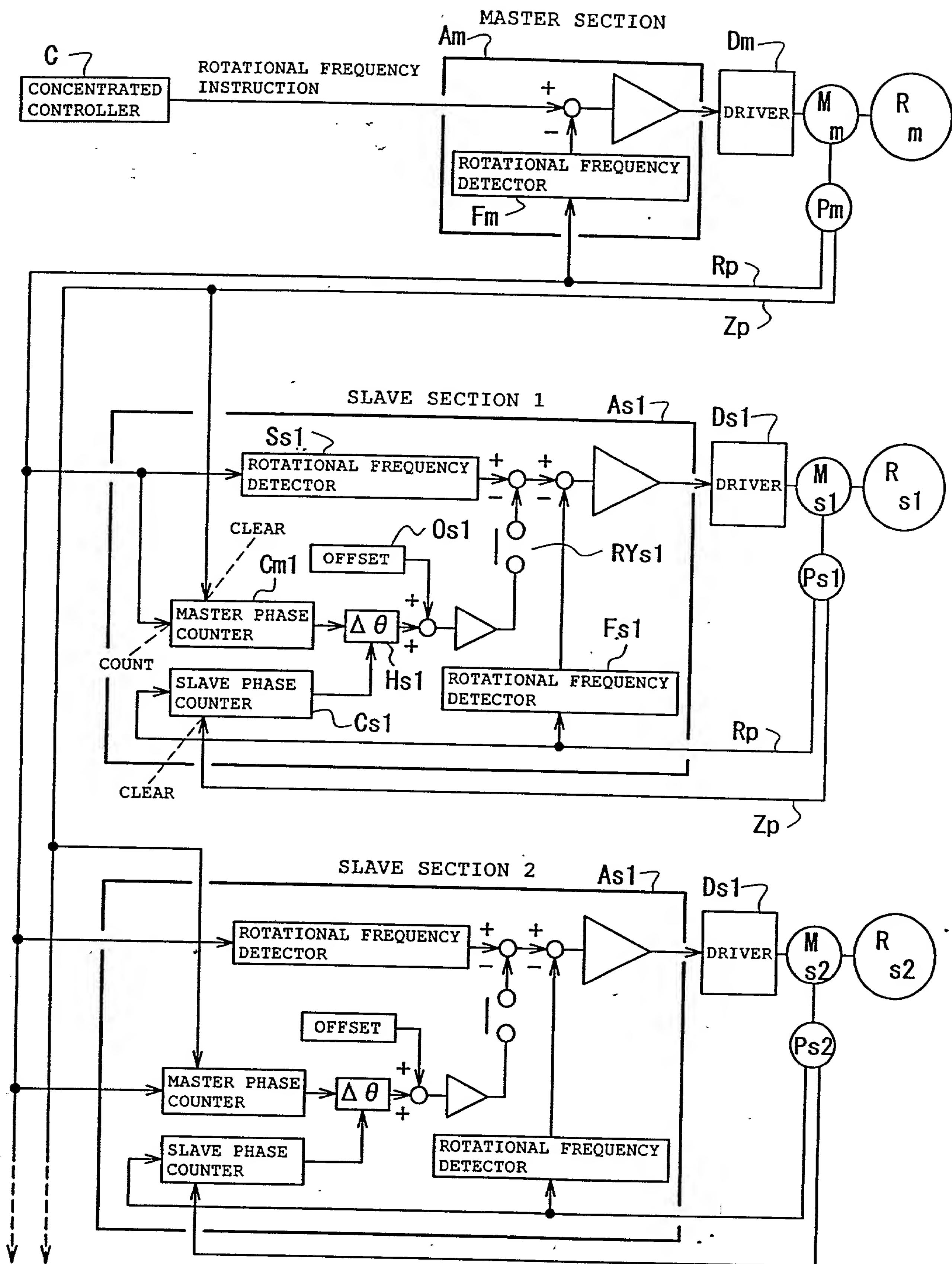


Fig. 2

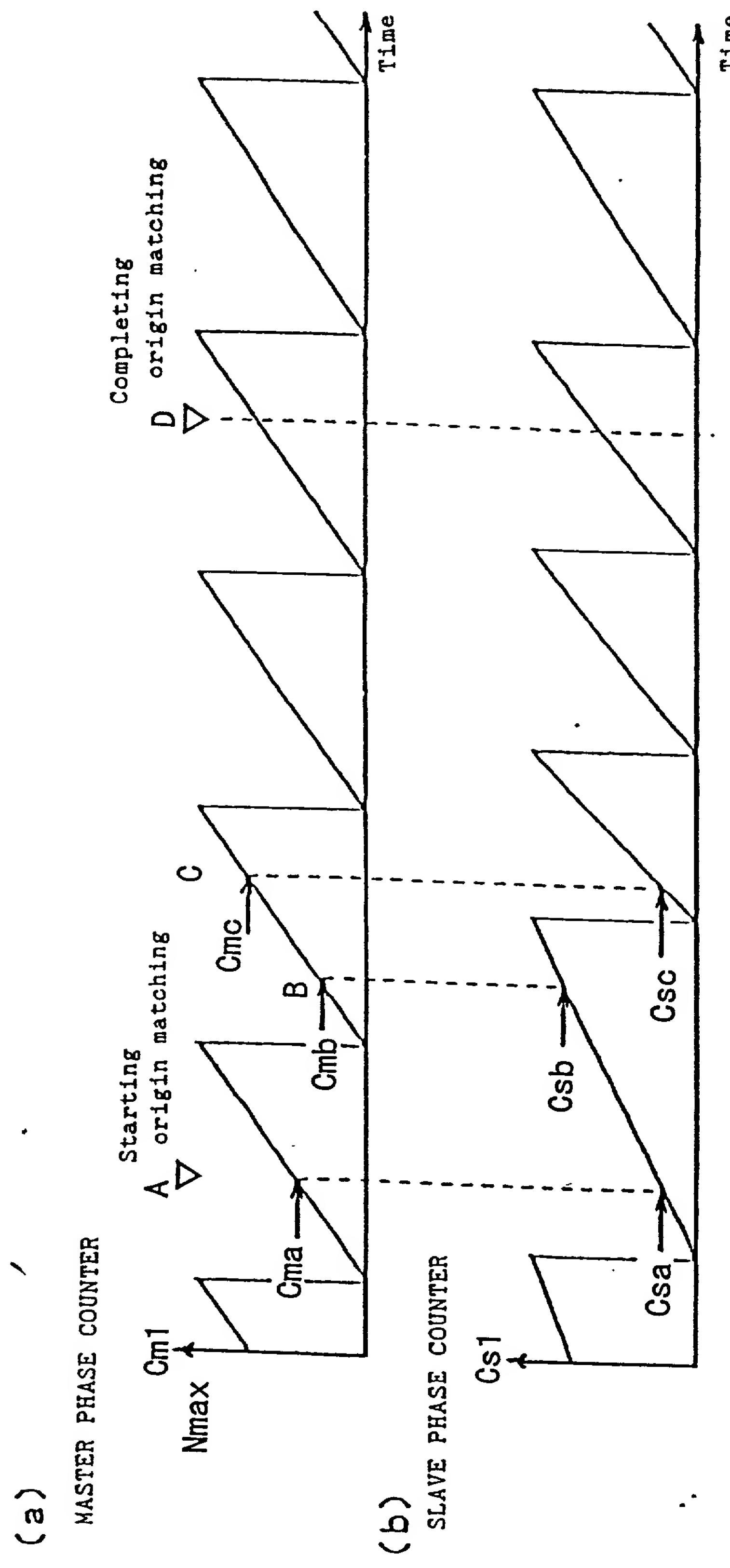


Fig. 3

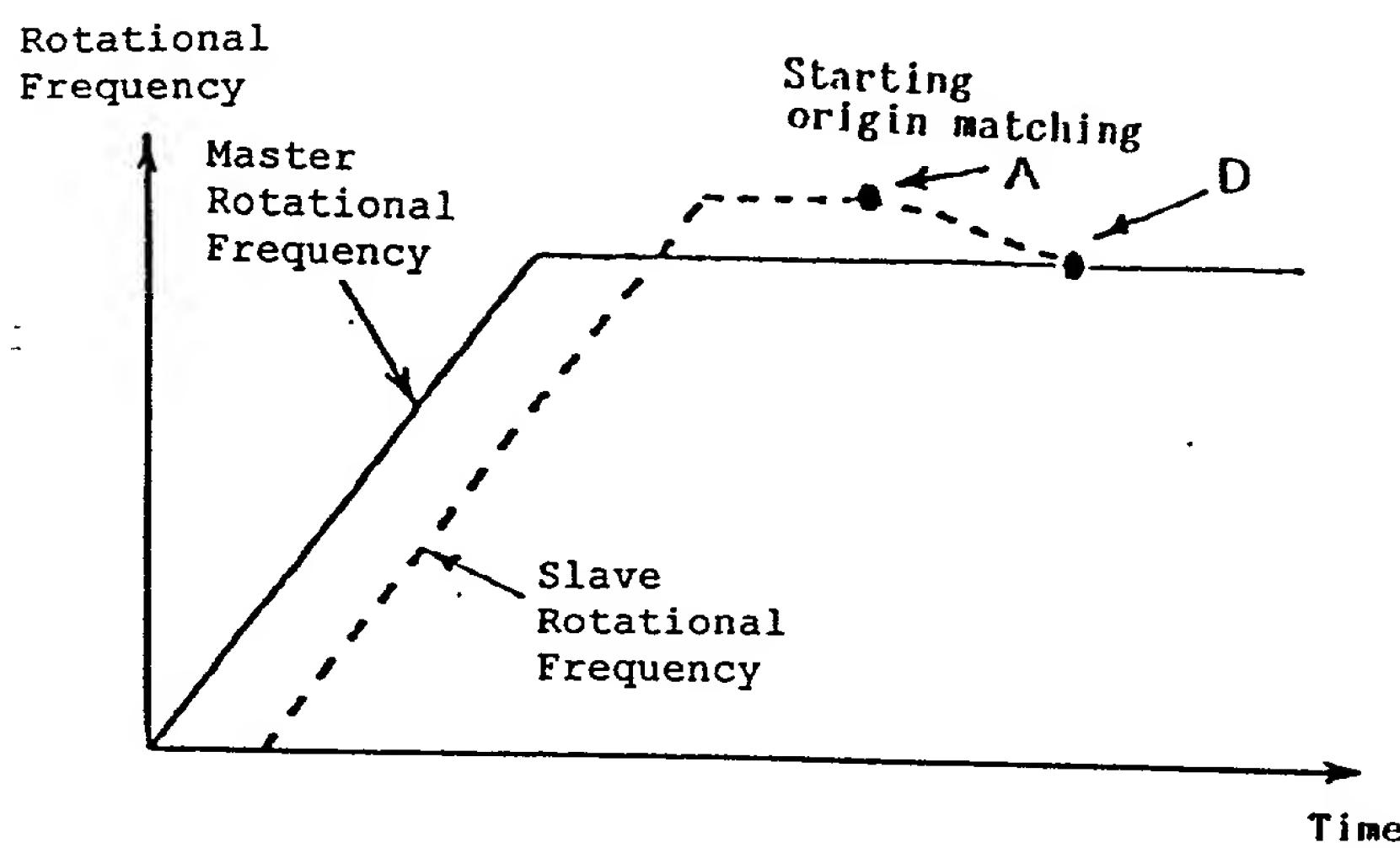


Fig. 4

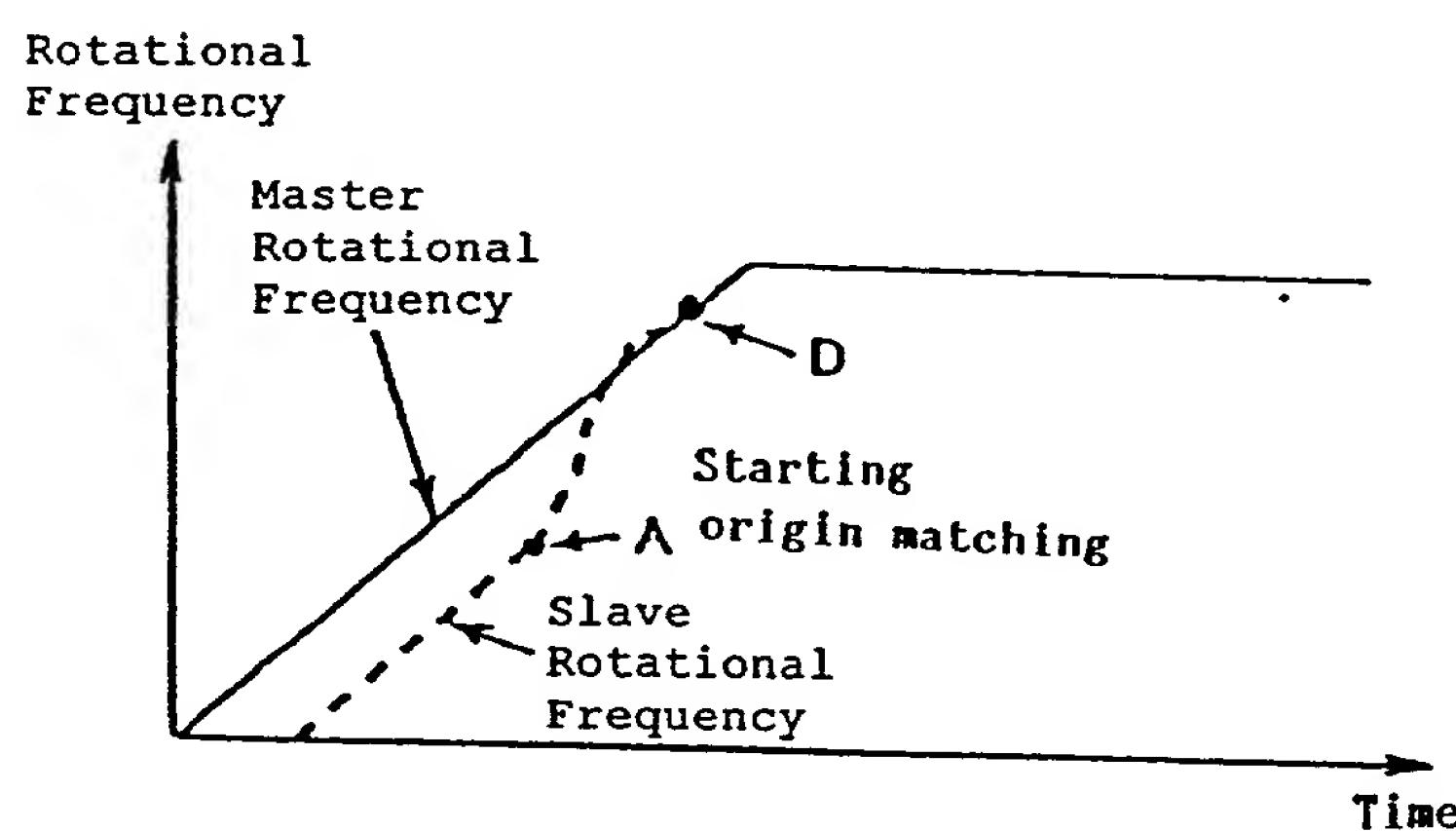


Fig. 5

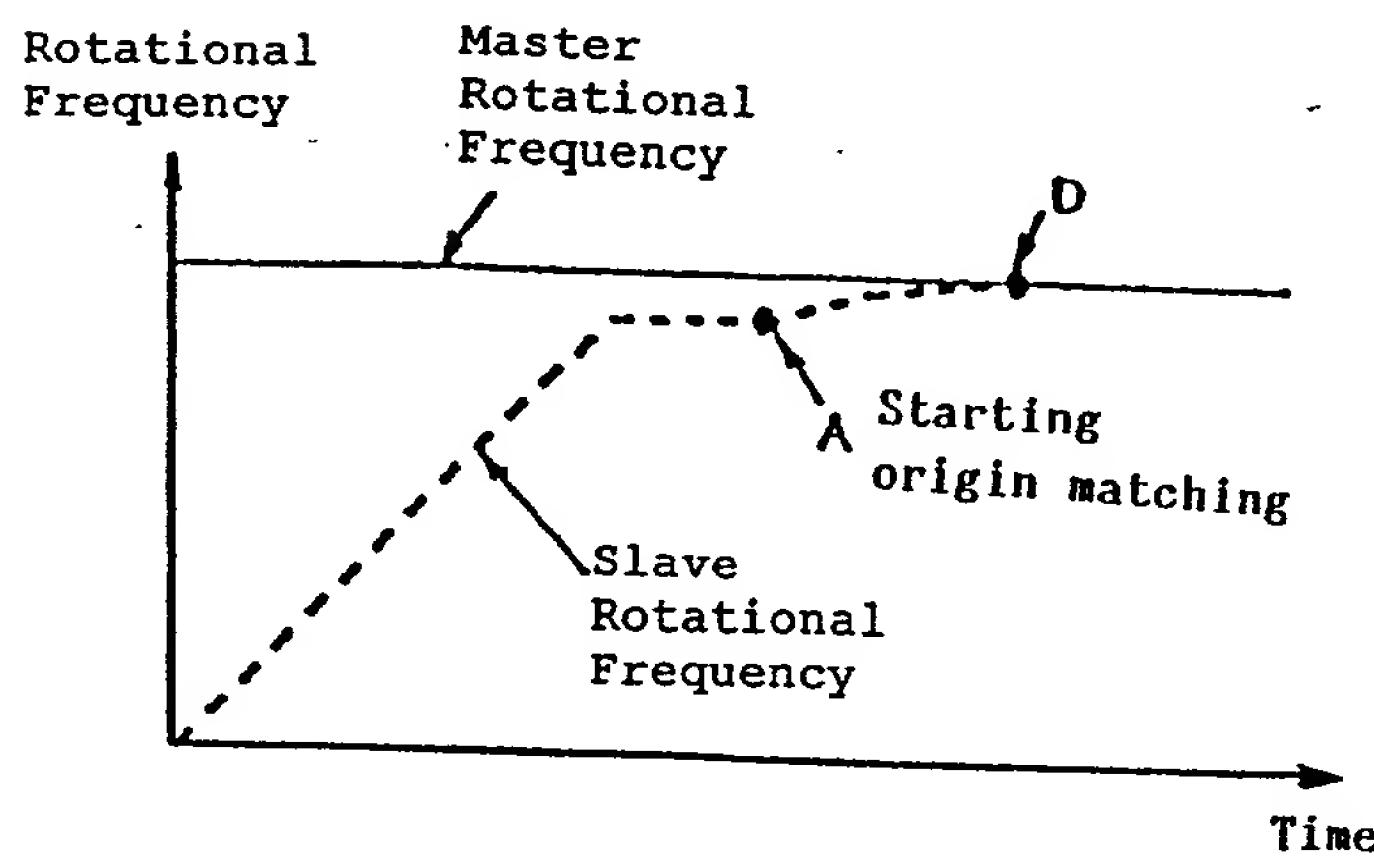
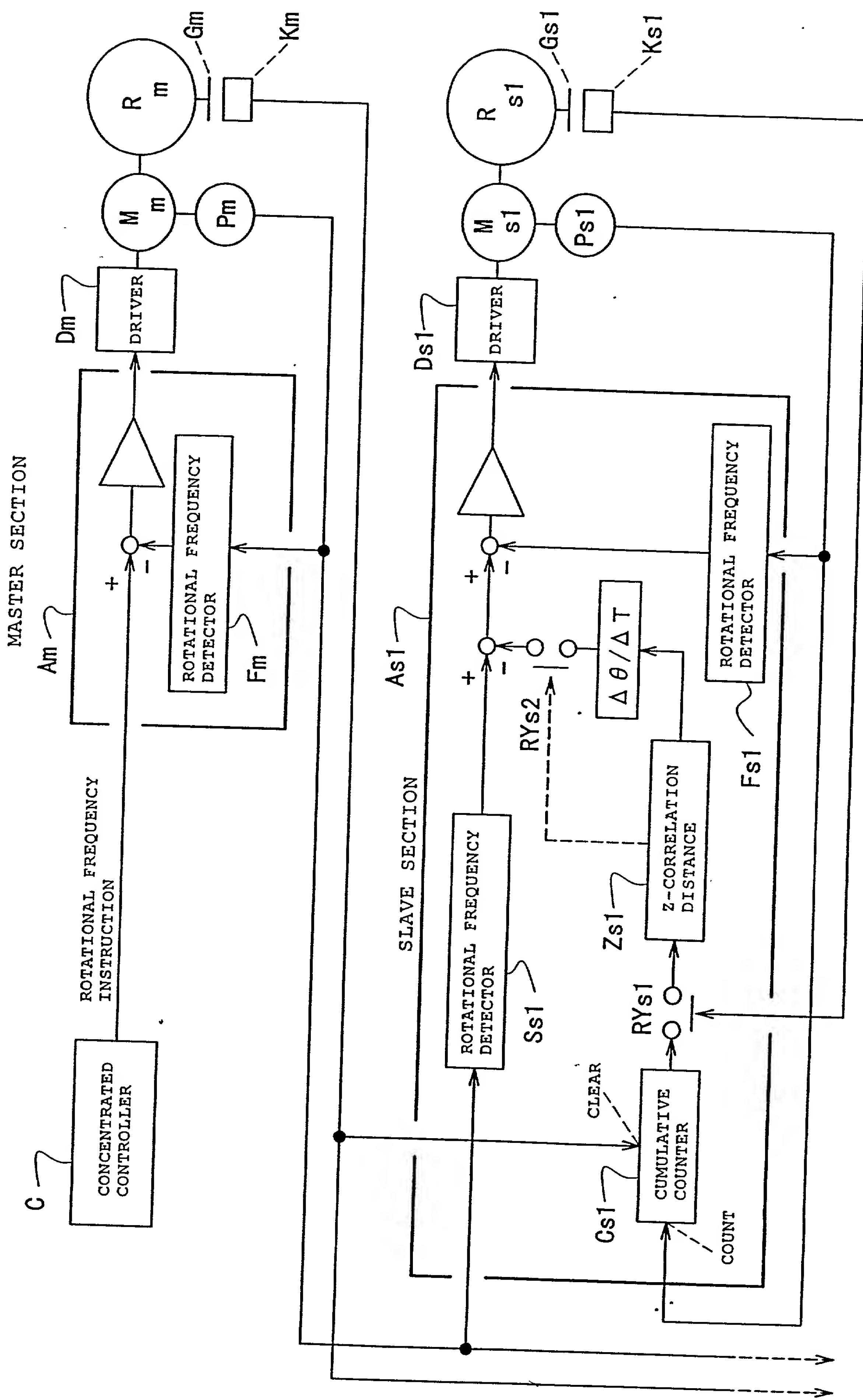


Fig.6



0528345

DECLARATION AND POWER OF ATTORNEY

SAT-38

Each below-named inventor hereby declares and says that:

My residence, post office address and citizenship are as stated below beneath my name; I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the invention titled: **METHOD AND DEVICE FOR SYNCHRONIZATION CONTROL**

which is described and claimed in the attached application, or Serial No. _____ filed _____ as amended to date; I have reviewed and understand the contents of the specifications and claims with all the above-mentioned amendments thereto, if any. I acknowledge my duty to disclose information of which I am aware which is material to the examination of this application in accordance with 37 CFR 1.56; and, if the benefit of 35 U.S.C. 120 is claimed below, as to subject matter of the claims not disclosed in any prior U.S. application in accordance with 35 U.S.C. 112, I acknowledge my duty to disclose material information known to me occurring between the filing date of said prior U.S. application and this application; the benefit of 35 U.S.C. 120 is claimed for

<u>SERIAL NO</u>	<u>FILED</u>	<u>STATUS</u>
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I claim the foreign priority benefits under 35 U.S.C. 119 of foreign application(s) for patent or inventor's certificate(s) filed less than 12 months prior to the filing of the application, or less than 12 months before the application(s) for which the above benefit of 35 U.S.C. 120 is claimed as follows:

<u>COUNTRY</u>	<u>SERIAL NO.</u>	<u>FILING DATE</u>
Japan	10/362567	December 21, 1998

and I have identified any foreign application(s) for patent or inventor's certificate(s) having a filing date before the earliest of the application(s) for which priority is claimed, or the present application, as follows:

<u>COUNTRY</u>	<u>SERIAL NO.</u>	<u>FILING DATE</u>
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BIERMAN, MUSERLIAN and LUCAS LLP, Customer No. 20311, Reg. No. 18,818; JORDAN B. BIERMAN, Reg. No. 18,629; CHARLES A. MUSERLIAN, Reg. No. 19,683; and DONALD C. LUCAS, Reg. No. 31,275; all of 600 Third Avenue, New York, New York 10016, Telephone (212) 661-8000, are hereby

appointed my attorneys, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, with the understanding that they represent my assignee, if any.

It is declared by undersigned that all statements made herein of undersigned's own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S. Code 1001, and that such willful false statements may jeopardize the validity of this application or any other patent issuing thereon.

INVENTOR: SIGNATURE DATE RESIDENCE AND POST OFFICE ADDRESS